SANTA CLARA-ALAMEDA
SAN BENITO WATER AUTHORITY

Condensation of the Report on Land Subsidence, Sea Water Intrusion and Aquifer Transmissibility Problems in the North Santa Clara Valley Basin

March 15, 1960

GB
1025
S383.C66
1960

SANTA CLARA-ALAMEDA
SAN BENITO WATER AUTHORITY

Condensation of the Report on Land Subsidence, Sea Water Intrusion and Aquifer Transmissibility Problems in the North Santa Clara Valley Basin

March 15, 1960

SANTA CLARA - ALAMEDA - SAN BENITO WATER AUTHORITY

BOARD OF DIRECTORS

FRANK J. POLAK, Chairman Santa Clara Valley Water Conservation District	THELO PERROTT, Board of Supervisors, Santa Clara County
EDWARD R. HANNA, San Benito County Water Conservation and Flood Control District	G. C. ARCHIBALD, Board of Supervisors, San Benito County
FRANCIS SILLIMAN, Santa Cruz County Flood Control and Water Conservation District	IRVIN DETHLEFSEN, Board of Supervisors, Santa Cruz County

DR. GEORGE L. SULLIVAN
Consulting Engineer

ALBERT T. HENLEY
Attorney

THELMA M. WRIGHT
Secretary

ROBERT E. PODESTA
Director of Public
Education

Report Prepared by:

CREEGAN AND D'ANGELO
CIVIL ENGINEERS
San Jose, California

CONDENSATION OF THE REPORT ON LAND SUBSIDENCE, SEA WATER INTRUSION AND AQUIFER TRANSMISSIBILITY PROBLEMS IN THE NORTH SANTA CLARA VALLEY BASIN

CONTENTS

	Page
Foreword	1
How Water Has Been Supplied to the Santa Clara Valley in the Past	2
Advantages of the Continued Use of the Ground Water Basin	3
Limitations on the Use of the Ground Water Basin in the Future	4
Sea Water Intrusion - An Academic Problem or a Realistic Problem?	4
Land Subsidence - Its Importance and Control	6
Aquifer Transmissibility - What it Means, How it Was Measured and How it Limits the Future Use of the Ground Water Basin	7
Summary of Basic Conclusions	10

SANTA CLARA - ALAMEDA - SAN BENITO WATER AUTHORITY

(TRI-COUNTY WATER AUTHORITY)

CONDENSATION OF REPORT ON LAND SUBSIDENCE, SEA WATER INTRUSION AND AQUIFER TRANSMISSIBILITY PROBLEMS IN THE NORTH SANTA CLARA VALLEY BASIN

FOREWORD

As in so many of the semi-arid areas of California, water supply is one of the foremost problems facing the people of the North Santa Clara Valley in planning and providing for their future.

Historically, the development of the Santa Clara Valley can be traced to the Franciscan Fathers who pioneered the territory in the Eighteenth Century. By the second decade of the present century, most of the suitable lands of the valley had been put to agricultural use. From 1920 to the present the valley has flourished as one of the agricultural centers of the nation.

During the 1940's, the trend of conversion from farming began to be felt as agriculture began giving way to residential and industrial land uses. If this trend continues, over 75 percent of the lands in the valley which were used for farming in 1940 will be converted to urban use by 1985.

In the past the North Santa Clara Valley has always received its water supply from natural local resources. However, the water requirements of the valley are increasing because of the change of land use, and soon the local resources will be inadequate to meet the requirements of the constantly growing community. In order to solve this problem and provide for normal growth, a supplemental water supply is required.

Planning for this necessary supplemental water supply involves the consideration of many problems. These problems are related to the source of the supply, the manner of developing and transporting the supply to the valley, and the manner of storing, purifying and distributing the water after it has been brought to the valley. The solution to these internal problems of storage, purification and distribution are prerequisite to the proper determination of the route by which water is to be brought into the valley. Certain of these internal problems are related to the subjects of:

1. Sea water intrusion,
2. Land subsidence, and
3. Aquifer transmissibility.

In 1958 and 1959 the Tri-County Water Authority retained the firm of Creegan and D'Angelo, Civil Engineers, to investigate and report on these three aspects of the problem. The authority feels that the findings of that investigation are important to the public understanding of the basic water problems of the Santa Clara Valley and is publishing the following condensation of that original report.

HOW WATER HAS BEEN SUPPLIED TO THE SANTA CLARA VALLEY IN THE PAST

Until recent years rainfall has been the sole source of water in the North Santa Clara Valley. To understand how it is possible to rely exclusively on rainfall for water supply in a land where rain occurs only during the four or five winter months and where all of the streams and many of the springs dry up for periods of six months or more each year, it is necessary to understand certain of the basic topographic, physiographic and geologic features of the Santa Clara Valley.

The Santa Clara Valley is situated at the south end of San Francisco Bay. This valley is bounded on the west by the Santa Cruz Mountains and on the east by the Mount Hamilton Range. All lands lying between these limits and north of the town of Morgan Hill constitute the North Santa Clara Valley which drains generally north into San Francisco Bay. The area described contains approximately 458,000 acres of land, of which 316,000 are topographically classed uplands, hills and mountains and approximately 142,000 acres are classed as valley floor.

The valley floor is geologically classified as an alluvial valley because of its underlying formations. These underlying formations consist of sands, gravels, silts and clays which have been transported and deposited in their present locations by ancient streams. The thickness of these alluvial beds above bedrock varies from several feet in the foothills to several thousand feet in the lowlands of the valley floor. The sands, gravels and silts are known as aquifers because water can flow through them. The clays are known as aquicludes because water does not readily pass through them. The aquifers store the winter rains and thus make it possible for periodic rainfall to serve the year-round water requirements of the valley. This alluvium is called the ground water basin, and in fact is a huge underground reservoir which is capable of serving the overlying lands.

It is interesting and fundamental to the understanding of the Santa Clara Valley water problems to know what happens to the rainfall which falls on the great watershed and how the ground water basin is recharged. Rain falling on the Santa Clara Valley does one of the following things:

A. Is directly used to promote the growth of plant life - this is called consumptive use.

B. Evaporates.

C. Percolates deep into the ground.

D. Runs off into the streams of the valley where -

  1. It percolates into the aquifers of the valley floor through the porous beds, or
  2. escapes to San Francisco Bay where it is wasted.

The ground water basin of the valley is naturally recharged by the deep percolating water (C) and the water which is percolated in the stream channels of the valley floor (D-1). During the past thirty years the Santa Clara Valley Water Conservation District has supplemented nature's natural recharge system by constructing a number of reservoirs in the foothills and percolation ponds throughout the valley. These reservoirs have captured much of the winter flow that would normally go to waste and have saved it for summertime release and percolation, thereby increasing the annual recharge to the ground water basin.

Through the history of its operation, the Santa Clara Valley Water Conservation District has continuously gauged the many streams of the valley which lead to San Francisco Bay. The District has found that on each stream there is a point beyond which no waters percolate from the streams into the underground basin; that is to say, all stream bed percolation takes place upstream from these points. If a line were drawn connecting these points in the various streams of the valley it would appear as the line shown on Plate No. 1, called the "Boundary between the pressure zone and the forebay zone". The pressure zone is that area of the valley floor lying inside this imaginary line. The area outside this imaginary line is known as the forebay zone. Generally speaking, logs of wells in the forebay zone show that sand and gravels (aquifers) are directly connecting from the surface to the underground basin, so that both rainfall and stream flow can percolate into the underlying aquifers. On the other hand, logs of wells in the pressure zone generally indicate there are layers of clay (aquicludes) lying between the surface and the underlying aquifers so that rainfall or stream flow generally does not have access to the underground reservoirs. These clay blankets cap this section of the valley floor and the ground water below this cap is under pressure, hence the terminology "pressure zone". The clay cap is occasionally penetrated by lenses of gravel which accounts for the fact that as late as the 1920's much of the Santa Clara Valley lying between San Jose and the San Francisco Bay was swamp land. These swamps were fed by artesian water rising from under the clay cap. The clay blankets are also pierced by many wells which have been pumping water from the pressure zone. With the increased pumping of ground water the levels and pressures of water under the pressure zone have dropped so that flowing artesian water is no longer a common phenomenon in the Santa Clara Valley.

The farmers of the valley early recognized that their water requirements could be met by pumping from the ground water basin. As the machine age advanced, the windmill pumps and shallow wells were replaced by deep wells capable of irrigating vast acres of farm and orchard land. The first industries of the Valley served this agricultural economy. These were the canneries which are still a mainstay in the economy of the valley Many of these canneries have their own wells and use great volumes of water in their food processes With the increase in the population of the valley, domestic water supply systems were developed around the combined use of well water from the valley floor and spring water from the mountains. Today, the ranchers, the industries, the waterworks and municipalities serving water to the valley rely primarily on the use of this vast underground supply.

ADVANTAGES OF THE CONTINUED USE OF THE GROUND WATER BASIN

The continued use of the ground water basin affords many advantages. Ground water basins are ideally suited for storing water because -

1. The underground basin is protected from contamination
2. The water is transported naturally, eliminating the need for construction of a surface transmission system .
3. As the water moves through the underground it is purified by natural filtration and requires no artifical treatment.
4. There are no evaporation losses from the underground reservoir.

Moreover, it is especially advantageous to continue the use of this ground water basin in the Santa Clara Valley because the existing water systems rely on the underground for their supply. To convert these systems to receive water from a surface supply would require capital expenditures of many millions of dollars.

LIMITATIONS ON THE USE OF THE GROUND WATER BASIN IN THE FUTURE

In view of the advantages cited above, it would appear desirable to continue to utilize the groundwater basin indefinitely. There is a limit, however, to the degree that a ground water basin can be safely used. This limit is technically known as the "safe ground water yield" of the basin. The term "safe ground water yield" is defined as the maximum rate of extraction of water from a ground water basin which, if continued over an indefinite period, would maintain ground water conditions which meet the following criteria:

Criterion 1:	Water levels are not so lowered as to imperil the economy of ground water users by excessive costs of pumping from the groundwater basin or by exclusion of users from a ground water supply.
Criterion 2:	Mean seasonal extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.
Criterion 3:	Water levels are not so lowered as to cause harmful impairment of the quality of the ground water by intrusion of other water of undesirable quality or by accumulation or concentration of degradants or polutants in the ground water supply.

Supplementary to the above accepted criteria, consideration should be given to the phenomenon of land subsidence as related to ground water practice.

The development of the Santa Clara Valley ground water basin is at the critical stage where, in view of the advantages of using the underground and the limitations on the safe use of the underground, a program of ground water management is necessary. As a prerequisite to such a program it must be determined where it is safe to continue existing ground water pumping practices, and where ground water pumping practices are unsafe and should be curtailed or abandoned in order to protect the remainder of the ground water system for use.

It was assumed that if water levels would not drop below the lowest recorded during the period 1938-1958, that the safe ground water yield, as determined by Criterion No. 1, would not be exceeded. The problem is then resolved to the investigation of aquifer transmissibility, sea water intrusion and land subsidence. Aquifer transmissibility is related to Criterion No. 2, sea water intrusion is related to Criterion No. 3 and land subsidence is related to the supplemental criterion. These three problems are the subject of this investigation.

SEA WATER INTRUSION - - AN ACADEMIC PROBLEM OR A REALISTIC PROBLEM ?

Many of the underground water basins along the sea coast of California are being degraded by an invasion of sea water into the fresh water bearing aquifers. In recent years this has become of great concern to the State of California, since approximately one-half of the State's water supply is derived from ground water sources. Recognizing the need to protect these important sources of supply for continued use, the State initiated a Ground Water Monitoring Program in the summer of 1953 under the authorization of Section 229 of the Water Code. The Department of Water Resources of the State of California administers this program which consists of systematic collection and mineral analysis of water samples from representative wells and important ground water basins throughout the State. The over-all objective of the program is to observe changes in the water quality, if any, which may be attributable to a specific source or cause. Prime among these specific sources or causes is sea water intrusion.

One of the ground water basins selected for observation under this program is the North Santa Clara Valley basin. Although the Ground Water Monitoring Program indicates that, despite the heavy pumping draft of recent years, there has been no advance in sea water intrusion in the North Santa Clara Valley, the State Department of Water Resources, in Bulletin No. 7, stated that there is a "threat of sea water intrusion" into the North Santa Clara Valley basin. This threat has been investigated in connection with the preparation of this report for the Tri-County Water Authority.

To understand the status of sea water intrusion in the North Santa Clara Valley, it is important to have a knowledge of what sea water intrusion is and how it occurs. Simply stated, sea water intrusion is a mixing of ocean water with the fresh waters of the ground water basin. This mixing, sometimes called intrusion or invasion, normally occurs when the water bearing strata of the ground water basin are directly exposed to the ocean or bay. Under this condition the only way that the sea water can be kept out of the fresh water supply is for the fresh water to be continuously flowing into the ocean. In order to maintain this flow, the water surface (or piezometric surface) must be higher than sea level. Where serious sea water invasion has been experienced in basins which are exposed to the ocean, the seaward flow of fresh water has been reversed or interrupted by excessive pumping in the basin. This excessive pumping has usually occurred near the coast. The pumping has lowered the fresh water elevations below sea level so that there has actually been a flow of salt water into the fresh, which has resulted in degrading or polluting the fresh water supply. In certain instances this has been so serious as to make the water unsafe for either domestic or agricultural use.

Not all ground water basins in valleys that front on the ocean or its inlets are directly exposed to the salt water source. In these instances, the fresh water bearing aquifers are capped by clay strata which, in effect, seal them from the sea water source. For sea water intrusion to occur in this type of aquifer there must be a direct access for the sea water into the fresh through shafts, excavations, well casings or ruptures in the confining impervious strata. Another way for sea water to invade an aquifer which has no front with the ocean is for sea water to advance in the upper porous strata (the strata above the confining clay layers) far enough to spill over an inland limit or interruption of the clay cap and thus mix with the fresh water. The third manner in which sea water can mix with fresh water, when the fresh water is sealed from the ocean, is through leakage of the clay cap itself. This aquiclude is not absolutely impervious and will permit certain seepage under the action of a sufficient differential of pressure from the two bodies of water being separated.

Well drillers' logs indicate that the North Santa Clara Valley ground water basin from Palo Alto to Milpitas is separated from the bay by confining clay strata. In Palo Alto and Milpitas these clay strata extend only a short distance inland so that the spilling type of intrusion could or may have occurred. These two cities were outside of the scope of the investigation. Between Mountain View and Alviso the clay cap extends well inland, with consistent traces to the limit of the pressure zone shown on Plate No. 1. Because of this confining clay cap, sea water invasion of the direct contact type is not anticipated. It has been suggested that the confining clay strata may be broken under the bay, permitting direct contact between sea water and fresh in the aquifer. Wells logs indicate that this is not probable since the clays become thicker closer to the bay. (As a matter of fact, one of the problems in locating a well near the bay consists in actually finding a water bearing aquifer.) The fact that pumping over the past twenty-five years has lowered the fresh water pressures in the bayside fringe of the Santa Clara Valley Basin (well below sea level) without any evidence of the fresh water basin being contaminated by sea water speaks for the integrity of the clay cap under the bay. Were there an interruption of this clay cap it would be expected that serious sea water intrusion would have been reported long ago.

There have been isolated instances of contamination of the confined aquifers in the past. These contaminations, however, were traced to abandoned wells which admitted tide water directly into the confined strata. The situation was corrected immediately by plugging these faulty wells.

The upper water bearing strata (unconfined) have been subject to sea water intrusion for many years and consequently have been abandoned as a source of fresh water. It is interesting to note that during the past twenty years there has been no change in water quality in these upper aquifers. This indicated that since 1939 the sea water front has not advanced inland. During this same period, the water quality in the underlying confined aquifers has not changed to any degree which indicates that so far there is no problem of leakage of salt water through the confining clay cap.

In view of these observations the following conclusions are made relative to the threat of sea water intrusion in the North Santa Clara Valley Basin:

1. It is not yet necessary to abandon the use of the ground water basin in any part of the main pressure zone of the North Santa Clara Valley (from Mountain View to Alviso) because of sea water intrusion.
2. The well water quality should continue to be observed through the existing State Monitoring Program so that should there be evidence of sea water intrusion in the future, remedial practices can be initiated. These remedies could include the importation of surface waters to the bayside areas of the pressure zones and/or the creation of a fresh water barrier by injecting a mound of fresh water (or reclaimed sewage effluent) along the bay.
3. Sea water intrusion will not be the determining factor in evaluating the safe ground water yield of the ground water basin.

LAND SUBSIDENCE - - ITS IMPORTANCE AND CONTROL

Land subsidence as it has occurred in the North Santa Clara Valley is a lowering of the surface of the valley floor with reference to mean sea level. This has caused much concern over the past thirty years and the Federal Government is continuously studying the rate, magnitude and causes of this subsidence.

The effects of land subsidence are varied. Outstanding among the problems and troubles resulting from subsidence are:

1. Bench marks of established elevation, which serve as a basis for control of regional engineering projects, are continuously changing in true elevation above the mean sea level.
2. Existing drainage projects, particularly regional storm and sanitary sewer systems, face premature obsolescence because of loss of gradient.
3. Structural damage and premature obsolescence of installations near San Francisco Bay occur because of lands settling below high tide elevations.
4. Land loss, flood damage, and premature obsolescence of flood control dikes and levies will result from the increasing encroachment of San Francisco Bay onto the lands of the valley.

It is the intent of this investigation to report on the subject of land subsidence as it is related to pumping practices in North Santa Clara Valley. No new studies were made but the work of the Federal Government was summarized.

It is a generally accepted theory that the subsidence experienced in the Santa Clara Valley is caused by a consolidation of underlying clays. The subsidence appears to be related to the general lowering of the ground water levels from year to year. This observation is consistent with the theory of consolidation of clays because the lowering of the ground water table increases the intergranular pressure in the underlying clay strata. When clays consolidate they first give up "free water" between particles. When this free water is squeezed out and the clay is still subject to high pressures it will give up "bonded water", which is actually a constituent part of the soil particle, with a resulting further consolidation. It is noted that during years when the water table is rising the subsidence is retarded and almost stopped, but it is not reversed. According to accepted theory, bonded water cannot be readily returned to the soil particle but free water could be returned if applied under pressures greater than the pressure exerted by the overlying soils. Practically, this is not feasible.

Government measurements indicate that from 1934 to 1954 the maximum subsidence in the North Santa Clara Valley was slightly over three feet. This maximum subsidence occurred along an axis generally between San Jose and Sunnyvale. This is an expression of the gross twenty-year trend. On a year-to-year basis it is difficult to detect a consistency in rates of subsidence or locations of maximum subsidence during the year.

The general conclusions drawn on the subject of land subsidence are:

1. Land subsidence is undesirable because of its adverse effects on the projects of the community.
2. Land subsidence is irreversible from a practical standpoint but can be retarded by raising static water levels of the ground water.

From this it can be understood that future programs which raise the underground water levels of the valley will, at the same time, tend to minimize the adverse effects of land subsidence.

AQUIFER TRANSMISSIBILITY - - WHAT IT MEANS, HOW IT WAS MEASURED AND HOW IT LIMITS THE FUTURE USE OF THE GROUND WATER BASIN

Water bearing strata made up of sands restrict the flow of water more than those made up of gravel, much in the same way that small pipes restrict the flow of water more than large pipes. The term "aquifer transmissibility" is a technical expression for the measure of the ability of an aquifer to transmit water under pressure. This transmissibility is actually a function of the size and distribution of the sands and gravels in the aquifer. The transmissibility of a manufactured aquifer can actually be tested in the laboratory. The aquifers of nature, however, are very inconsistent in the distribution of grain size and other transmissibility characteristics and, consequently, no direct measurement of the transmissibility of natural aquifers can be made. The subject of aquifer transmissibility is very important, however, because it constitutes one of the limiting criteria for the use of a ground water basin. That criterion states that no more water should be pumped from an aquifer than can be recharged to it. If, in a given area of the valley, water is pumped from the ground at a faster rate than it can be returned to that area through the aquifers, the area in question is being overdrawn and requires supplemental surface water. Problems arise when this overdrawn condition persists despite heavy recharge to the basin at large.

The Department of Water Resources has concluded in Bulletin No. 7 that ground water potential of the aquifers in the pressure zone of the North Santa Clara Valley has already been reached or exceeded because the aquifers do not have the ability to transmit water fast enough to meet present demands. This conclusion is correct to a degree but it is not believed to be correct throughout the entire pressure zone. The problem is to determine what areas of the pressure zone -

(a) cannot be adequately served by the underground water basin at the present,

(b) can be adequately served by the underground basin now and for a period into the future and,

(c) will always be able to derive their water supply from the underground system.

Although direct measurements of the transmissibility of natural aquifers cannot be made, it is possible to determine how much water has been transmitted through the aquifers in the past when there is a long history of well measurement. This method was used in the investigation of aquifer transmissibility in the North Santa Clara Valley. This is a conservative approach to the problem since the only assumption made is that in the future the transmissibility will be as much as has been observed in the past. Records of the Santa Clara Valley Water Conservation District are unusually valuable in this instance. These records show that during the wet cycle of 1938-43 the rate at which water was recharged to the North Santa Clara Valley underground basin exceeded the recharge that would be possible during a future period of average rainfall and annual importation of 60,000 acre feet of water. Experience, however, will be the only true measure of the effect upon transmissibility of a future recharge program which puts more water into the ground than has occurred in the past.

Using the historical approach, records covering twenty years on almost 400 wells were analyzed and the following steps taken to prepare Plate No. 1 which effectively summates the aquifer transmissibility studies:

1. The Santa Clara Valley was subdivided into blocks of a grid, each block being approximately 4.3 square miles in area. Each block was then studied as an independent unit.

2. Hydrographs for every well in each block were plotted for the period of 1938 to 1958. These hydrographs show the annual low static water level and the annual high static water level. The hydrographs of the wells in each block were then averaged to obtain a representative hydrograph for the block.

3. In studying these hydrographs it was known that during years that the slope of the hydrograph was rising, more water was being transmitted to a block than was leaving it (either by underground outflow or by pumping). During years that the slope of the hydrograph was falling, more water was leaving a block than was being transmitted to it. During any period of time when the water level at the beginning and end of the period is the same, it is known that the total amount of water entering the block is the same as the total amount leaving the block. These facts are based on the equation -

   Inflow is equal to outflow plus storage.

   A rise in the hydrograph indicates positive storage and a fall indicates negative storage.

4. It was observed that in practically all blocks of the grid the hydrographs were on the up slope from 1938-43. Equally consistent with this observation was the observation that following 1943 there was a decline in the hydrographs of each block of the valley. It was further noted that after this decline the hydro-

graphs of some of the blocks again started rising, while others either leveled off or continued to decline. The consistent rise from 1938-43 was the result of a period of heavy rainfall and operation of the newly installed water conservation facilities. While these initial water conservation facilities increased percolation on some of the streams as much as 100 percent, natural recharge from rainfall (as compared to artificial recharge by waters released from storage reservoirs) was the outstanding component of total recharge.

5. The assumption was made that the average annual rainfall in the future would be the same as the long term average in the past.

6. Studies of land use and water consumption during the period of 1938 to 1956 were correlated to determine the gross water consumption in each of the blocks of the valley for each year of the period. These studies were then projected to the assumed ultimate land use in each block to determine what the ultimate gross water demand for each block would be. The amount of water that was supplied by rainfall each year was subtracted from the gross water consumption for that year. The end result was the determination of the amount of water pumped from the ground water system in each block each year.

7. Total natural and artificial recharge to the ground water basin at large was computed for each year of the 1938-56 period.

8. Trial and error technique was applied at each block to determine what percentage of the total recharge had gone into each block. This inventory was then totalled and adjusted, so that the total change in storage in the valley, plus the total water pumped from the underground, equalled the total recharge to the basin at large.

   It is interesting to note that the necessary adjustments were minor. The water consumption and the recharge figures agreed very closely with work done independently by The Department of Water Resources and published in Bulletin No. 7.

9. From these data Plate No. 1 was prepared. Plate No. 1 represents the summary of the study and is color coded to indicate:

   (a) BLUE - Areas of the Valley which have an ultimate annual water requirement less than the maximum amount of water which has been transmitted to the area in the past. It is concluded that these areas can always be served from the underground.

   (b) RED - Areas of the Valley in which the greatest amount of annual recharge in the past is less than the present requirements. These areas now need surface water to supplement the ground water supply.

   (c) YELLOW - Areas of the Valley in which the greatest amount of annual recharge in the past is more than the present requirements but less than the estimated ultimate requirements. These areas may or may not be able to be served exclusively from the underground. This decision should be made only after several years since it is possible that the maximum amount of water which has been transmitted to each block during any year in the past may be exceeded in the future under the increased artificial recharge program.

10. Companion studies to those outlined in Steps 1 to 9 were made using other conventional approaches to the same problem. As expected, it was found that blocks of high transmissibility were in areas where the underlying strata consisted of low percentages of clay, high percentages of gravel, and low values of drawdown by pump test. The converse was true in the blocks having low transmissibility.

The conclusion of the aquifer transmissibility studies are shown graphically by the color coded Plate No. 1.

SUMMARY OF BASIC CONCLUSIONS

Sea Water Intrusion

Apparently the lower aquifers of the Santa Clara Valley which are being used for fresh water supply are sealed off from San Francisco Bay by clay strata.

On the basis of water quality data furnished by the State Well Monitoring Program, it does not appear that sea water intrusion is a probable threat in most of the aquifers of the North Santa Clara Valley which front on San Francisco Bay. Exceptions to this observation may be in Milpitas and Palo Alto, where either local ground water of poor quality or an overtopping of the confining clay layers is probably the cause of contamination of the underground supply.

Local and state water authorities should control major dredging operations in San Francisco Bay to prevent rupture of the sealing strata.

Land Subsidence

Land subsidence is important to consider because of the undesirable effects. Subsidence can probably not be reversed, but it is expected that the rate of land subsidence may be measurably slowed and possibly halted by adequate replenishment of the underground reservoir.

Aquifer Transmissibility

The limiting criterion defining the extent to which the aquifers of the valley can be used for municipal, industrial or agricultural water supply appears to be the ability of these aquifers to transmit water at rates equal to present or future demands. The detailed conclusions as to the potential of these aquifers are shown on Plate No. 1.

Further Study

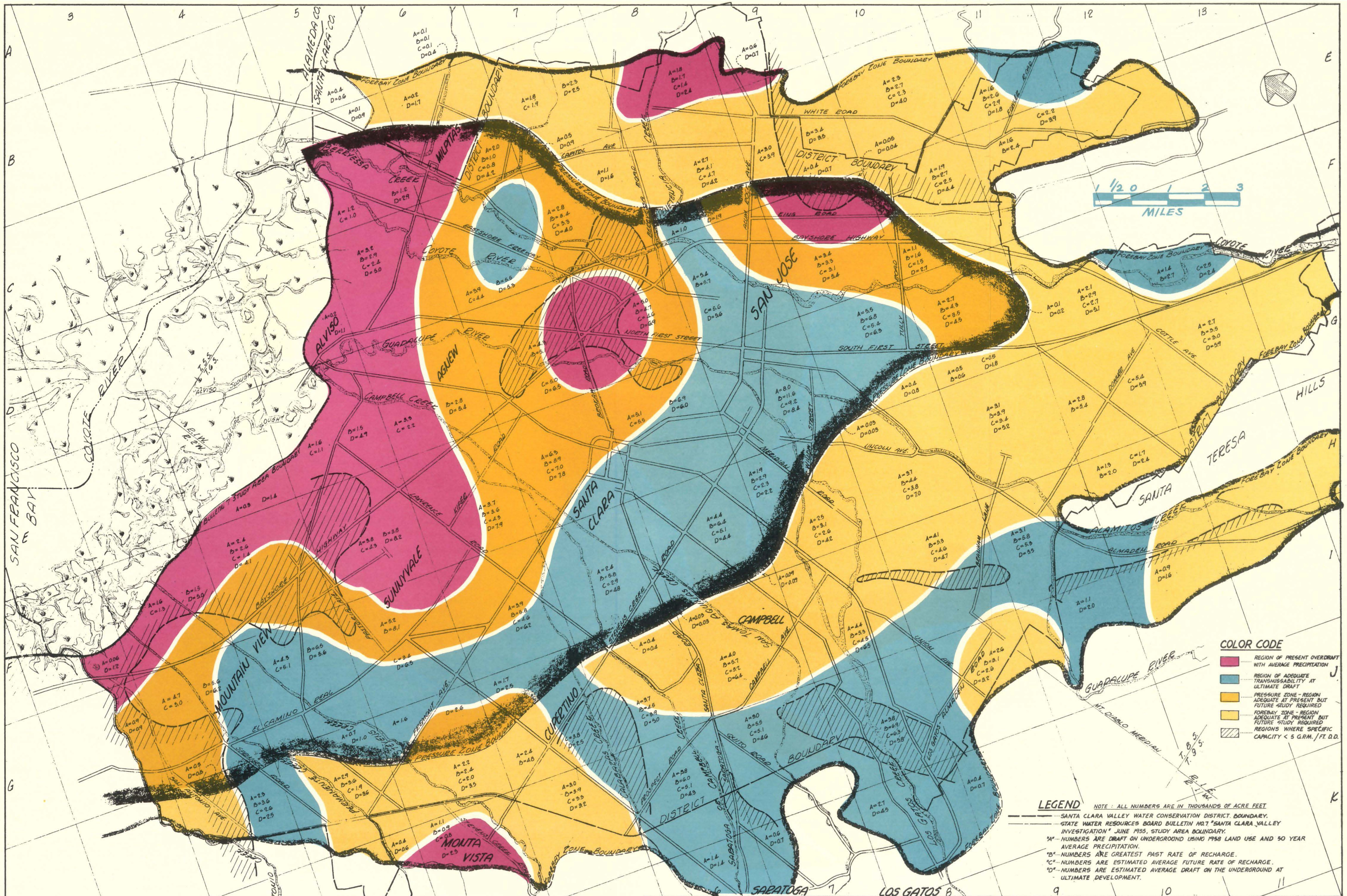
Continued use of the underground water resources of the North Santa Clara Valley is vitally important to the economy of the area. One very important problem which remains to be solved in the planning of the ground water management is the proper location of percolation facilities and the determination of the optimum rates for recharge (natural and artificial) such that -

(a) Water levels will be raised in areas marked blue and yellow on Plate No. 1,

(b) swamp conditions will not be re-established in former artesian areas that are presently developed or have a potential of being developed, and

(c) the water table at the points of recharge in the forebay areas will not be raised so as to damage orchards and other land improvements at those points.

Copies of the original technical report from
which this text was condensed are available
for review at the offices of the Santa Clara
Valley Water Conservation District, 15420
Almaden Road, San Jose, California



COLOR CODE

- 🟥 REGION OF PRESENT OVERDRAFT WITH AVERAGE PRECIPITATION
- 🟦 REGION OF ADEQUATE TRANSMISSABILITY AT ULTIMATE DRAFT
- 🟧 PRESSURE ZONE - REGION ADEQUATE AT PRESENT BUT FUTURE STUDY REQUIRED
- 🟨 FOREBAY ZONE - REGION ADEQUATE AT PRESENT BUT FUTURE STUDY REQUIRED
- ▨ REGIONS WHERE SPECIFIC CAPACITY < 5 G.P.M. / FT. D.D.

LEGEND

NOTE : ALL NUMBERS ARE IN THOUSANDS OF ACRE FEET

— — — ······ SANTA CLARA VALLEY WATER CONSERVATION DISTRICT BOUNDARY.

—— - —— ······ STATE WATER RESOURCES BOARD BULLETIN NO.7 "SANTA CLARA VALLEY INVESTIGATION" JUNE 1955, STUDY AREA BOUNDARY.

"A" — NUMBERS ARE DRAFT ON UNDERGROUND USING 1958 LAND USE AND 50 YEAR AVERAGE PRECIPITATION.

"B" — NUMBERS ARE GREATEST PAST RATE OF RECHARGE.

"C" — NUMBERS ARE ESTIMATED AVERAGE FUTURE RATE OF RECHARGE.

"D" — NUMBERS ARE ESTIMATED AVERAGE DRAFT ON THE UNDERGROUND AT ULTIMATE DEVELOPMENT.

REV.	DATE	DESCRIPTION	BY
0	3/23/59	RELEASED FOR REPORT	JC

CREEGAN AND D'ANGELO
CIVIL ENGINEERS
SAN JOSE CALIFORNIA SARATOGA

DESIGNED BY: ——
DRAWN BY: D.R.G.
CHECKED BY: P.J.C.
APPROVED BY:
DATE: 3/23/59

SANTA CLARA — ALAMEDA — SAN BENITO WATER AUTHORITY

GROUND WATER STATUS - 1958

SCALE: AS SHOWN
JOB NO. 58-17
SHEET ⑰ OF 17
DRAWING NO. E 5817-17
REV. 0